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Project Title

MIMOSA

Section 2

TECHNICAL / MANAGEMENT PROPOSAL

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FORM M4: Brief Technical Summary

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Technical Summary

Technology in Telematics has reached a point where dramatic improvements can be obtained in the way in which health care systems work, and as a result achieve better service to patients by streamlining information flows in the medical world. Data communication, storage and retrieval, mutual understanding despite borders, distances and systems heterogeneity, are all equally essential in health care information systems. The aim of MIMOSA-Medical Images Management in an Open System Architecture- is to achieve the interoperability by designing an open environment for managing, exchanging, and distributing biomedical images and related information.

An appropriate architecture must define a common terminology, common functionality and adhere to the Open System philosophy: using a high level of abstraction in the specifications in compliance with ISO standards, guaranteeing the users' autonomy with respect to manufacturers and the way in which they will use the system.

Different aspects of the information system will be formalized, being: semantic content and organization of the information, format and encoding of the data items, and data access and distribution services. The following functions will be analyzed and modelled: - Data acquisition, including: image format (such as ACR-NEMA and Papyrus), and relevant information filing. - Data consultation, including: prefetching, filtering (eg user worklist), access control. - Archive management, including: archive hierarchy (short term vs long term), security (backup and recovery), deletion policy (purge). - Relationship and cooperation with other information systems (eg HIS/RIS).

The MIMOSA system will be implemented and demonstrated at 8 pilot test locations spread over Europe and evaluated by users. To assure the quality, productivity, and portability of the system, advanced software development technologies (eg CASE tools) will be used throughout the specification, design and implementation phases.

The evaluation will fine tune the system, provide a detailed assessment of its medical opportunity, and ensure the commercial viability of the resulting products.

A global look at current developments and needs will guide the project, which will be based on the results of prior AIM projects, and on existing technologies and standards, but build on and extend them substantially. This implies significant enhancements of existing standards and the participation to standardization efforts. Throughout the project, there will be concertation with other relevant projects to coordinate efforts and to contribute to the creation of a consensus view.

FORM M4D: List of Deliverables
(Overall Plan)

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Sequence Number	Workpackage Identification	Title	Year/Month	Nature	Type
D22A	WP2.2	FIRST REPORT OF REQUIREMENTS	1 / 4	R	P
D21	WP2.1	FINAL REPORT ON TERMINOLOGY	1 / 6	R	P
D22B	WP2.2	FINAL REPORT ON REQUIREMENTS	1 / 12	R	P
D41A	WP4.1	ASSESSMENT OF STANDARDS BASED ON DEFINITIONS	1 / 12	R	P
D35A	WP3.5	FIRST MIMOSA OVERALL SPECIFICATIONS	2 / 3	S	R
D5A	WP5	SPECIFICATIONS AND DOCUMENTATION FOR SYSTEM DEVELOPMENT	2 / 6	S	I
D42	WP4.2	PROPOSAL FOR STANDARD FORMAT CONFORM OSI	2 / 6	R	P
D33	WP3.3	DATA DICTIONARY FOR BIOMEDICAL IMAGES	2 / 9	S	I
D41B	WP4.1	COMMON STANDARDS DATA DICTIONARY	2 / 9	R	P
D44	WP4.4	MIMOSA ARCHITECTURE ASSESSMENT	2 / 9	R	P
D43	WP4.3	REPORT ON EVALUATION COMMUNICATIONS/NETWORK	2 / 9	R	P

FORM M4D: List of Deliverables
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(Continued...)

Sequence Number	Workpackage Identification	Title	Year/Month	Nature	Type
D5B	WP5	SOURCE CODE, GENERATION PROCEDURES	2 / 12	T	I
D35B	WP3.5	FINAL MIMOSA OVERALL SPECIFICATIONS	2 / 12	S	R
D6	WP6	EVALUATION REPORT ON THE USE OF MIMOSA IN THE MEDICAL PRACTICE	3 / 12	R	P
D41C	WP 4.1	FINAL REPORT ON STANDARDS	3 / 12	R	P

2.1 PROJECT OBJECTIVES AND BACKGROUND

2.1.1 Objectives

The MIMOSA consortium believes that technology in Telematics has reached a point where a dramatic improvement can be obtained in the way in which health care systems work and as a result achieve considerably better service to patients by streamlining information flow in the medical world. While more and more valuable information is generated each day (in any medical institution) which needs to be properly managed in order to be used, new computer tools now enable the handling of large amounts of data. These comprise an increasing number of types: images, speech, documents etc.

A vital link in health care information systems, either paper or computer based, is now communications; storing and retrieving data must be followed by mutual understanding between all users despite their differences, across borders, and at any distance.

This requires us to plan in terms of interoperability so as to permit heterogenous systems to work together. Any appropriate architecture must define common terminology, common functionality and must adhere to the Open System philosophy. Differences in regulations and usage vary so much that defining such an architecture is a complex task. The European Community is now a reality involving increasing movement of people, so the requirement is clear: information must follow people and be understood wherever needed.

Improvement of health care requires better management of medical (clinical, biological, image, management ...) information. Biomedical image data must be seen as a subset of general medical information and must be handled within a generalized medical information system (such as a HIS).

However biomedical images exhibit specific features:

- 1) The manipulated objects are numerous and complex. The relationships between such object are complex, in particular with respect to their semantics.
- 2) Image data are produced by heterogeneous sources resulting in differences in format which must be made transparent to any information system.
- 3) Workstations used for image interpretation making use of such images also generate new image objects after image processing. Such acquired and processed objects must be managed uniformly by the information system.
- 4) Image archives are huge and require special access techniques making use of the semantics of image objects (e.g. prefetching).
- 5) Images are also accessed on the basis of general administrative and medical data and thus image, administrative, and general medical information systems cannot be isolated.
- 6) Images are required to be accessed both locally and remotely for a variety of reasons by different physicians. A flexible and secure human computer interface and access tool must be provided.

For the above reasons it is our belief that biomedical image objects must be managed by a dedicated information system taking into account the specific requirements for such objects, communicating with all other components of the medical information management network and integrated in a (Open System) client/server architecture.

The objectives of the MIMOSA project are thus:

- 1) To specify user requirements in terms of information management and communication in the field of biomedical imaging.
- 2) To model the image data structure and interfaces to the outside world, based on these requirements, and conforming to existing and proposed standards in particular ISO, leading to European recommendations for a standard biomedical image data model.
- 3) To implement and evaluate that model to assess its functionality, especially with respect to the transport of acquired images, archiving strategies, and links to other information systems.

In general terms: the MIMOSA project is intended as a significant contribution in the area of biomedical image standards, focusing on the image data structure in an open system architecture, permitting access to such image data from components of a generalized medical information system. The MIMOSA project will handle levels 5,6,7 of the ISO/OSI model and above (e.g. ISO9595).

The common underlying data model will be based on requirements specified by European biomedical image experts, defined by a team of European data modelling experts, and validated in European institutions (2 in France, 2 in Germany, 1 in U.K., 1 in Italy, 1 in Luxembourg, 1 in Belgium). Prototype evaluation concerns links to the generalized information system, image formats, workstation interfacing, and remote access over all appropriate standards (e.g. ISDN). It will generate a variety of products: an archiving system compatible with any image source or workstation, a data base suitable for use in PACS, an extension of a generalized medical information system capable of handling images.

Health care is expected to improve because of:

- 1) enhanced generalized access to biomedical images for: routine patient care, retrospective and prospective clinical research, evaluation of image processing, and assessment of cost effectiveness.
- 2) remote access to biomedical images from other European medical organizations (including health clinics) over standard communication channels.
- 3) the building of multi-centric reference image data sets, in particular for teaching purposes.

The most important benefit of MIMOSA will be the establishment of an image database management system NOT dependent on the platform, hardware (communications and computing) or manufacturers, where all database interfaces are clearly defined.

A second major benefit is that this will permit the exchange of data between different systems (over a variety of bridges) permitting trans-European mobility of medical image data.

Other benefits will include:

- the definition of a European data specification for input to CEN, based around ACR-NEMA, but compatible with OSI.
- the creating of tools for a common European human computer interface for users to communicate with such databases, facilitating the exchange of medical personnel throughout Europe and reducing training costs.
- the ability to create and manage large reference image databases.

2.1.2 STATE OF THE ART

A. Biomedical image management: conceptual modelling

A.1 Data model

The design of a information management system involves:

- an abstract view point subsuming data, processing and communication ;
- a technical view point, subsuming hardware, software (e.g. languages, data bases, libraries) and documentation.

The abstract view point is centred on a model in which data are described as structures, processing as procedures and communications as protocols. This description which is provided by the data dictionary must be precise, relevant, updatable, consistent and non-redundant.

The general model can be split into several layers, each of them being associated with specific models, and therefore to a description language.

The ANSI Standard Planning and Requirement Committee (SPARC) proposed the following three layer model:

- a conceptual layer describing data syntax and semantics: data structures, integrity/consistency constraints, global management rules (e.g. data relationships). It does not refer to any uses or users, any access or implementation;
- an external layer describing the view of the data owned by a users class, i.e. the data subset and their access rights;
- an internal layer including a logical and a physical level.

Usually, two supplementary processes, not described in the ANSI/SPARC methodology, are needed in order to complete and implement such a model:

- a normalization process to structure the data;
- a organizational process to locate data and processing, and to describe the processing.

Figure 1 summarizes the tasks involved in the modelling process.

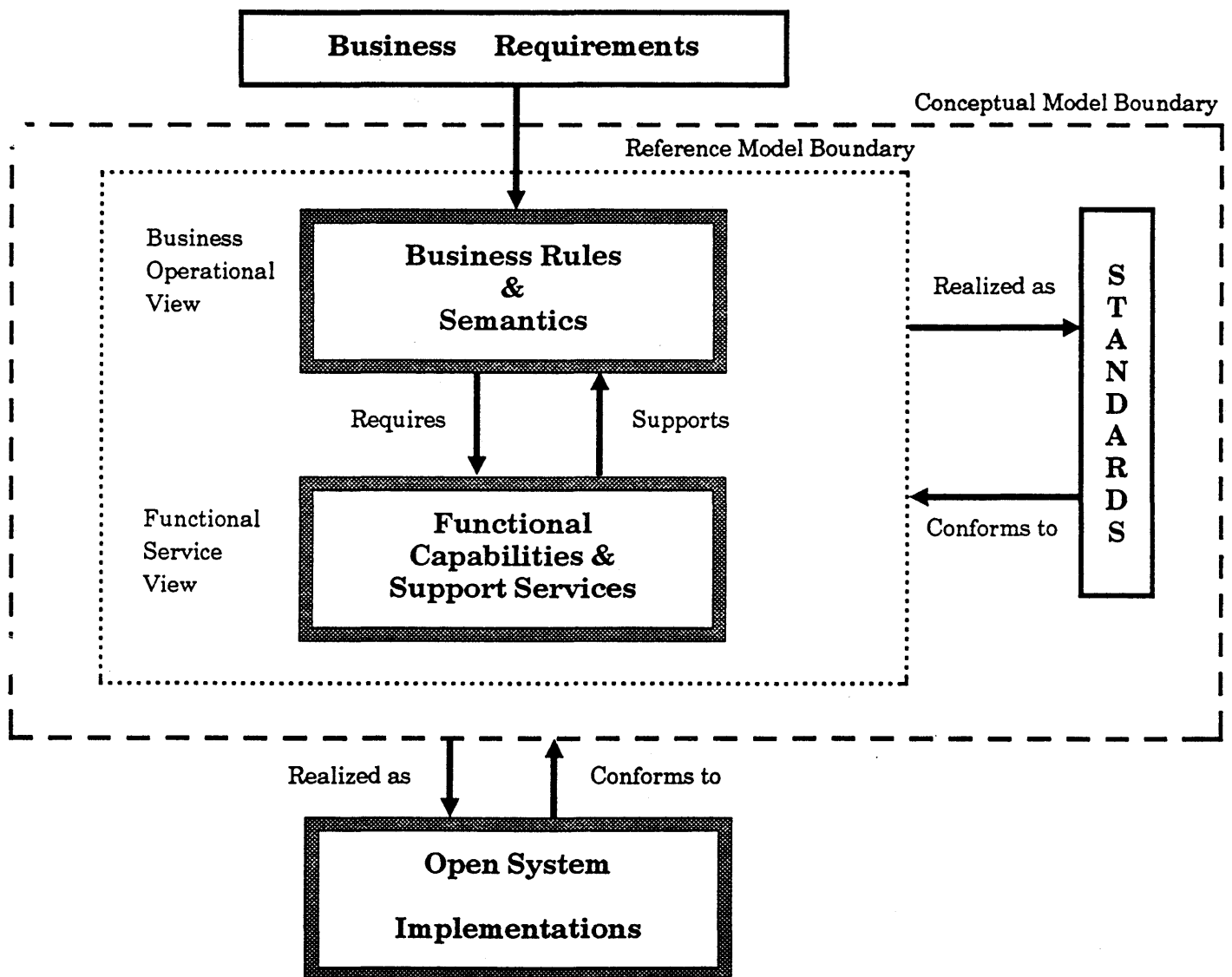
Components ↗ Tasks ↘	DATA	PROCESSING
EXTERNAL	External data structures Users' views	Views, applications
CONCEPTUAL WHAT ?	Relationships Entity classes Owner Attributes Input/Output Constraints: Referential Integrity Inclusion	Process Status Status transitions Events Flow diagrams Status diagrams
NORMALIZATION	Consistency checking Aggregations Generalisation/Specialisation	
ORGANIZATIONAL WHERE ? HOW ? WHO ? WHEN ?	'LOGICAL' Data localisation Documents Static resources	Processing localisation Real time/batch 'FUNCTIONAL' Description of the transactions processing streams
PHYSICAL	Format Encoding Physical database structure	Encoding: Algorithms, Languages Backup

Figure 1: Information Management System modelling concepts

These tasks are strongly related to the ISO Open System Conceptual Modelling methodology (Fig 2). "Business Requirements" and "Open System Implementations", tasks which do not belong to conceptual modelling, correspond to the external and physical layers of the ANSI/SPARC methodology.

The normalization task can be compared with the standard assessment required by ISO methodology. The "Business Rules and Semantics" and the "Functional Capabilities and Support Services" tasks correspond to the conceptual and organizational tasks for the data and for processing respectively.

The Open System Conceptual Model



by ISO/IEC JTC1 SWG

A.1.1 MAIN MODELS

Setting up the IMS model necessitates at least three kinds of model:

- a data model which represents the static information. The main data models are: the relational model, the E-R model, including its extension, the binary relationship model, semantic networks and object-oriented models;
- a data flow model which describes the system functionality by means of data streams and processes;
- a state transition model such as Petri nets.

Some approaches integrate into a single model both static and behavioral aspects such as: Sowa's conceptual structures [11], the semantic data models and object oriented models.

Relational and E-R models are very similar. They list all entities or entity classes involved in the Information Management System (IMS) and their relationships. Extensions of the E-R model permit management of some of the integrity and consistency constraints.

The binary relationship model is a specialisation of the relational model, involving only relationships between two entities or entity-classes. It is, however, more powerful because it includes the description of inclusion/exclusion constraints between entities or relationships, and other types of constraints.

Object-oriented models cover a large class of models including the concept of a data constructor, derived from the abstract data type theory, and describe not only the data structure but also its behaviour. Main constructors are "aggregation" to merge several entities, "generalisation/specialisation" to create a taxonomic hierarchy of entities, "list", "set", "powerset" and "bag" to solve cardinality constraints.

A.1.2 CASE TOOLS

As models involve in IMS specifications are of various kinds, inconsistencies between the various perspectives on the data (static, dynamic...) are likely to occur. CASE (Computer Assisted Software Engineering) tools are used to integrate into a unique and coherent methodology, such specifications.

These tools include a combination of diagramming techniques, text descriptions, and a dictionary which stores text description and information relating diagrams, icons (for the user interface) and text. They provide a step-wise refinement (top-down) process to build the system specifications. They may include tools to automatically generate portions of codes from the specifications.

These tools are based on methodologies derived from the data models, data flow and state transition modelling. The most known methodologies are SADT based on the E-R model and flow diagram analysis, NIAM based on binary relationship model and, in France, MERISE based on E-R and Petri net model.

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A.2. Data access and Interchange

Images and related alphanumeric and graphic data must be accessed from various components of any general Medical Information System. Data within a Biomedical Image Management System (BINS) can be accessed through Local Area Networks (LAN) existing on the scale of a department, a hospital or a campus, and Wide Area Networks (WAN) allowing data transfers between hospitals and medical institutions.

As a consequence, such a system (a BINS) must be an Open System, able to communicate with a range of heterogeneous systems (medical imaging sources, radiologist, physician or therapist workstations) and with other components of the Medical Information Systems.

The only way to manage this heterogeneity in a convenient and flexible manner is to interface the data base to networks and remote applications in compliance with the ISO Open System Interconnection reference model (OSI), and to rely on established standards (ISO, CCITT, ANSI, CEPT, ECMA, etc...), as far as communication protocols are concerned. A particular mention concerns the ACR-NEMA Standard number 300-1985 and its more recent draft in 1988, resulting from a joint effort of the American College of Radiology (ACR) and the National Electrical Manufacturer Association (NEMA). Its objective is to provide a standard interface to facilitate the interfacing of image sources, workstations, digitizers, which is a pre-requisite for the development of image data communications. The major contribution of the standard is to provide a general nomenclature of the main items to be associated to medical images (patient and study identification, description of acquisition parameters for the various imaging modalities and the image and related graphics presentation characteristics).

It must be stressed that the lowest layers do not comply with existing communication protocols, which makes their implementation a difficult and expensive task.

Nevertheless, some implementations have been reported in the literature (Ringleben (1988), Good (1988)). In addition, the underlying conceptual schema of the ACR-NEMA recommendations has been used to design ACR-NEMA image data bases. Such implementations have been carried out, for example, at the University of North Carolina (Hemminger (1986)).

Data access and interchange protocols can also be reviewed using the OSI reference model. Particular attention has to be paid to the Application layer, since it is clear today that ISO standards will be dominant in a long term.

The main (provisional) standards for the application layer are:

- *File Transfer Access and Management (FTAM) [ISO 8571].*
This standard provides not only transfer capabilities but also a remote access to a distant file for selective read/write/update operations or management functions (renaming, creating, modification of file attributes or access rights, etc...).
- *Virtual terminal protocols such as BCVT (Basic Class Virtual Terminal Protocol).*
The current wide spreading of windowing systems, like X-Window which provides similar services to applications in a distributed context may probably become alternative standards in the near future.
- *Document interchange for office automation.*

The ISO has defined two categories of standards, the ODA (Office Document Architecture) and the ODIF (Office Document Interchange Format). The first focuses on the document structure and internal formats, whereas the second is communication orientated to transmit or access documents from a remote site.

- *Electronic mail.*

The X 400 series recommendations of the CCITT provides a complete set of standard procedures for message creation, structuring, forwarding and receiving (ISO 8505 - MOTIS).

- *Remote Database Access (RDA) [ISO DP 9579]* provides remote access to relational (SQL) databases.
- *Document Filing and Retrieval (DFR) [ISO SC18/WG4/N356]* provides search facilities and structured filing based on attributes contents for multimedia documents.
- *Remote Procedure Call (RPC) [ISO DIS 10148]* provides facilities for distributing applications over a network.
- *Abstract Syntax Notation (ASN.1)* is a Presentation Transfer Syntax Language to represent the information exchanged between applications in the OSI/ISO model

In conclusion, a choice is required for a Biomedical Image Management Systems as to whether it should comply with general purpose standards such as X 400 or ODIF, or will specific protocols such as ACR-NEMA be prominent, in spite of additional costs and other drawbacks.

B. Standardization activities in the area of healthcare

B.1 IEEE P1157 MEDIX (1986)

The objective of the IEEE P1157 Medical Data Interchange Committee (MEDIX) is to "specify and establish a robust and flexible communications standard for the interchange of data between heterogeneous healthcare information systems". To reach this goal, MEDIX proposes to define an architecture, a data model, services and protocols compliant with the OSI application layer.

B.2 Health Level 7 (1988)

The HL7 group is a consortium of users and vendors aiming at specifying and promoting a standard for the exchange of data in the area of healthcare, and especially in HIS. A joint technical working group has been created to achieve convergence with MEDIX.

B.3 ACR/NEMA (1985)

The ACR/NEMA standard (ACR/NEMA Standard 300-1985 and 300-1988) has already been mentioned in the previous paragraphs. A number of working groups are still involved

in various aspects of the definition and validation of the standard. An important release (V3.0) is in discussion which should bring significant extensions, among which are included:

- definition of folders,
- definition of alternate lower layers (allowing communication using OSI and TCP/IP protocols instead of the current low level protocols)
- definition of a generic set of new commands based on the OSI-CMIS standard,
- definition of service class and conformance,
- extensions of the dictionary (HIS/RIS interface, Nuclear medicine, etc).

B.4 CEN-TC251 (1989)

The European standardization body (CEN) has been involved in standardization in the area of healthcare by means of two actions.

- The first one involves the European Workshop for Open Systems (EWOS). The mission of EWOS project team 007 was to explore the suitability of existing standardization efforts in medical informatics and the application of Open Systems Standards in this area, in order to orient future work. This work comprised a general survey of all relevant projects within the RACE, AIM and ESPRIT programs (for example by Mattheus (1991), Ratib (1991b), and Passariello (1991)), activities of various organisations such as MEDIX, HL7, WHO, and interviews of actors of the medical, industry and healthcare administration sectors. A report (EWOS 1990) summarized the situation and giving guidelines to orient future work toward standardization in this area.
- A second action is managed by the technical committee TC 251 (Medical Informatics). A number of working groups have been recently set up to attempt standardization.

C. Medical image management: Implementation

C.1 HIS-RIS

The dramatic increase of operating costs in the area of healthcare makes rationalization efforts very urgent in order to improve the cost effectiveness of healthcare.

Hospitals have to manage an increasing amount of information which must be used to enhance the effectiveness of the system instead of diminishing it.

This issue is particularly acute because of the numerous tasks a hospital must fulfil (patient care, administrative and financial management, research, education, etc) and the numerous professionals involved in these tasks (doctors, nurses, administrators, researchers, professors, etc) (Rienhoff (1989)).

Hospital information systems (HIS) have been developed for more than 20 years to deal with these information processing requirements. (Melrose (1981), Bakker (1991), Scheffer(1991)). Most HIS are implemented on central mainframes, which are accessed by a large number of terminals (typically over 1000 for a 1000 bed institution). Three kinds of HIS suppliers can be listed: i) computer vendors such as for instance IBM, ii) software companies providing dedicated systems, and iii) in-house developed systems. At first, the kind of data to

be managed by a HIS was considered unrestricted but emphasis was given to financial and administrative data (patient identification and tracking, billing, employee salaries, etc), rather than to medical records. Today most systems include sub-systems able to manage other additional medical data such as (e.g. laboratory data, Radiology Information Systems). Present HIS are de facto limited to the management of data characterized by a large number of very short records. Thus, it is not surprising that the first attempts to manage medical images were not successfully integrated within existing HIS. These first experiments were developed by university groups and medical imaging vendors rather than HIS designers.

C.2 State of the art in the area of PACS

C.2.1 First generation PACS projects

Three major periods can be identified. The first (1980-1985) was an exploratory period . A lot of prototypes were developed all over the world (but mostly in the USA) by university groups and industrial companies to assess the impact of PACS in radiological practice. These experiments were motivated by medical needs, technological opportunities, economic issues, and industrial challenges. These various, more or less precise motivations were catalysed by the enthusiasm of physicists and researchers for this new technology.

The major experiments were carried out in the radiology department of the University of Kansas, in partnership with NCR (Dwyer III (1982), Bulatek (1983)), the radiology department of the New York University medical center (Maguire (1982), Horii (1983), Cywinski (1983)), the department of radiological sciences of UCLA (Huang (1983a), Huang (1983b)), the Mallinckrodt Institute of Radiology at St Louis (Cox (1982), Blaine (1983)), the University of Pennsylvania at Philadelphia (Arenson (1982), Arenson (1983)), and the University of North Carolina in Chapel Hill. None of these experiments succeeded in providing a clinically useful system in the anticipated time. The difficulties encountered by these pioneer groups enabled researchers to understand more fully the PACS concept. The major problems encountered were due to:

- i. technological reasons, mostly related to the immaturity of available technology (expensive, non reliable, and globally not very efficient). The lack of standards for the digital sources interfacing also required tremendous efforts to provide only specific and temporary solutions.
- ii. methodological reasons; these projects aimed at too many goals, without clear milestones. Consequently, a lot of energy was spent with little concrete outcome. Ergonomics and organisational issues were underestimated leading to systems which could be little used in a clinical context.

The difficulties and disillusion which marked the end of this exploratory period have been reported in the literature (for instance, Maguire (1986)).

C.2.2 Second generation PACS projects

Second generation projects (1985 and 1989) were generally better thought out and more specific. They aimed at assessing PACS design and impact (ter Haar Romeny (1987), ter Haar Romeny (1989), Barneveld Binkhuysen (1989), Lodder (1988), Ottes (1989)). Such

well focused studies were numerous and significantly contributed to the understanding of PACS, especially concerning the organization of radiology departments (Parrish (1986), Rogers (1986)), the evaluation of the impact of PACS in particular clinical contexts such as paediatrics (Kangaroo (1988)), in teleradiology (Seshadri (1988)).

Other studies dealt with more technical aspects, for example communication issues (Blaine (1988), Reijns (1988)), workstations, the technical and ergonomic viewpoint (Cox (1988), Horii (1988)), and the organization of archiving (Martinez (1988), Bizais (1989), Gibaud (1990)).

The first industrial PACS were also produced at this time, by Siemens and the Philips and AT&T joint venture.

The former was based on a high performance console (Diagnostic Reporting Console), offering retrieval facilities based on a hierarchical folder concept and digitally interfaced to Siemens imaging modalities. This system was installed at several sites (Nosil (1988)).

The CommView system (Philips/AT&T) turned out to have a very positive influence on the general development of PACS although its functions were limited by the mode of image acquisition (frame-grabbing). The implementation approach (Stockbridge (1986)) and the very pragmatic architectural choices (Hedge (1986)) as well as the concern for ergonomics (Kasday (1986)) promoted a number of key concepts. This system was also installed at several sites and permitted testing of a wide range of PACS aspects such as their medical impact (Mun (1989), Braudes (1989), Levine (1990)). More recently, a few systems were installed in Europe, in particular in Italy (mainly at Trieste, Ferrera, and Bologna) and in Great-Britain (St-Mary's hospital in London).

During this period the first version of the ACR/NEMA standard was issued. This ACR-NEMA standard was aimed to satisfy a important need in the area of medical image formats and interchange protocols. Nomenclature and data formats recommendation have been well accepted by the PACS community (Hemminger (1986), Creasy (1986), Good (1988), Budler (1988), Herforth (1989)), but the lower levels of this protocol have been criticized.

C.2.3 Third generation PACS projects

A new period seems to have started in 1990, characterized by a new generation of wide scale PACS projects. This tendency could be observed at the NATO ASI "PACS in medicine", in Evian, October 1990.

Five such projects can be listed. The first is described in a tender (MDIS (1990)) prepared by the MDIS technical development team of the US army and aims at installing PACS in three military hospitals and to equip a teleradiology hub, in the first stage. During a second stage, the acquisition of PACS for 9 other hospitals and the purchase of 12 additional teleradiology centres (accessible from 96 nodes) are anticipated.

A second project concerns Hammersmith hospital in London which has the same objective of a filmless operating system to function in 1993 (Glass (1991)).

A third similar project deals with equipping a new hospital in Vienna in Austria (Mosser (1991)).

The fourth project is the PACS as developed at UCLA which has been constantly developed since 1983 and its scale and integration level mean that it can now be considered as an hospital wide system.

A fifth project is currently in development at the Hopital Cantonal of Geneva, with the same objective of an hospital-wide system (Ratib (1991a)).

Such initiatives mark a break with the former period and may reveal the beginning of a certain developmental maturity. This new wave of optimism relies on technological and methodological issues that we are going to briefly review in the next paragraphs.

C.2.4 Current context for PACS development

- **Technical Maturity**

Regarding communications, Ethernet has a very wide diffusion, available on various media including fibre optics. The relatively low performance of Ethernet can be remedied by clustering the network into small functionally related sub-networks (clinics, technical units). More powerful technologies such as FDDI are becoming available and this evolution should continue in the future. As far as higher level protocols are concerned (layers 3-4 of the ISO-OSI model), TCP/IP provides a general solution until ISO protocols become widespread.

A very wide range of software tools are available today to develop and integrate distributed applications. The availability of relational database management systems (rDBMS) makes information management much easier.

SQL and an increasing number of fourth generation languages (4GL) assist the design, development and maintenance of such applications (forms and reports generators, etc). Client/server architectures facilitate the development of distributed applications.

The current technology of storage media, based on high-speed magnetic and optical disks enables archives of several hundred gigabytes at affordable costs.

Workstation technology has evolved considerably and products with a very high performance/cost ratio can now be achieved. These workstations provide suitable hardware platforms to build medical workstations at a very low cost.

- **Methodology for the development of generalized information systems.**

Previous medical image management systems have stimulated discussion between users and designers about design and assessment issues and has resulted in a general agreement about solutions or elements of solutions.

A central issue, the integration within a general information system is now approaching consensus among most groups. The proposed approaches are not specific to the management of biomedical images (which is encouraging) and rely on the inter-operability of distributed systems. Future integrated systems must be based on modular components, purchased from several vendors and implemented on heterogeneous hardware, and integrated in an open system architecture. The advantages of this approach are: i) decreased dependency on vendors, ii) reduced development and maintenance costs, and iii) increased flexibility. A

prerequisite to reach a high level of integration is to use an open system architecture complying to the ISO/OSI model. This inter-operability between all the subsystems composing the integrated information system requires a common conceptual model.

As previously mentioned, these issues have been properly addressed a few years ago and important efforts are currently spent toward standardization at an international level by a number of institutions and standardization bodies.

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2.2 PROJECT PLAN

2.2.1 Technical Approach

1) RATIONALE

The major functions of Medical Imaging Management systems deal with:

- the production of medical images, mostly but not uniquely in radiology departments,
- the transfer of images to diagnostic (or therapy planning) workstations within (or outside) the radiology department, so that images can be interpreted ; this interpretation mostly results in a report.
- the dissemination of the reported examinations to referring physicians,
- the archiving and retrieval of data,
- the confidentiality and reliability of data. These functions are involved all over the patient care process (diagnosis, therapy planning, patient follow up) but also for teaching and research.

The PACS experiments carried out during the 1980-1990 decade have shown the importance of the integration of the PACS within the Hospital Information System.

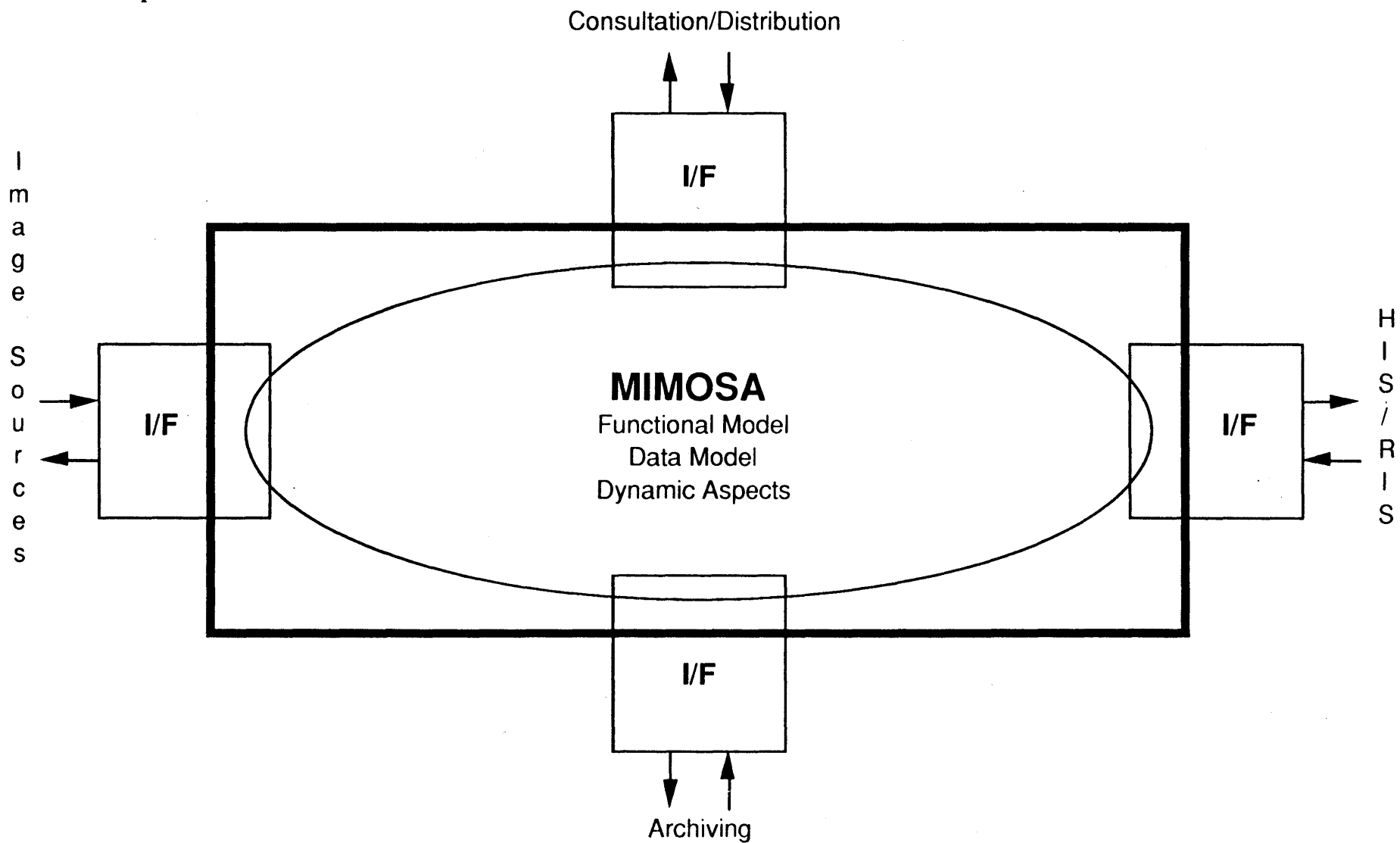
A prerequisite for such an integration is to comply with an open architecture allowing communication in an heterogeneous environment.

As a matter of fact, information processing in the field of healthcare has become such a challenge that big monolithic HIS are no longer suitable since they have proven too complicated to build and maintain and are hard to interface to medical equipments. As a consequence, distributed and departmental approaches seem more effective: the MIMOSA system will be open and interoperate with the four major entities dealing with medical information (cf figure 1).

The MIMOSA project handles the information communication and management aspects of Medical Imaging. The final objective is to build and evaluate in a number of test sites a system solution capable of handling a wide variety of medical images, using a suitable architecture and providing the basic services expected from end-users of Medical Image Management Systems.

MIMOSA puts strong emphasis on creating modular, re-usable software with methods kept separate from the specific applications. This will be accomplished by creating an open software environment which targets application generation on multiple platforms.

MIMOSA concept:



Following are our guidelines for the project, from a technical viewpoint:

- Evaluate the present European situation from a functional and technological point of view.
- Survey the current and future needs by interviewing representative image producers, users and researchers and continuously monitor these needs throughout the project.
- Review and assess applicable standards and contribute to medical image standards.
- Link with other bodies involved in the field and establish collaboration and synergy with other European, national and regional programmes for efficient and unduplicated efforts.
- Develop an optimal strategy reviewing possible technical solutions versus cost effectiveness.
- Definition of the structures and requirements for medical images management in an open system architecture.
- Study and definition of interoperability of image management system with its environments.
- Design of systems at pilot locations which implement our structures and meet our requirements.
- Evaluation of these pilot tests.

The technical approach is built on several skills and experiences available within the consortium:

- database management systems
- data organization and modelling
- software engineering methodologies
- object-oriented paradigm
- medical image processing and analysis including 3D representation and multimedia imaging
- PACS
- communication standards
- networks and network management
- computer and network performance
- medical information systems
- medical practice
- project management.

Key topics explored in the MIMOSA project are:

- Conceptual modelling
- Open systems
- Medical image management systems
- Client/Server architecture.

These topics are presented in detail hereafter.

2) CONCEPTUAL MODELING

A necessary condition to reach a good integration is to rely on a common conceptual model of the data and activities which have to be shared between the different components of the system.

The elaboration of a such common model has 4 major aspects:

- 1- a common terminology
- 2- a common data model
- 3- a common functional model
- 4- a common operational model.

1- Common Terminology

There could exist a confusion in the terms as a consequence of several factors:

- variety of the people producing or making use of medical imaging,
- multiplicity of imaging modalities,
- different languages in use in the european community.

All actors have to agree about consistent descriptions of the objects which have to be shared or exchanged between the different parties.

This work will be carried out in relationship with other groups working in this area (HL7, CEN/TC 251). The constitution of a database of terms seems to us a good means to clarify terminology, and a possible entry to feed the dictionary to be used for data modeling.

2- Common data model

Based on a common identification of concepts, a common data model has to be designed. It will include all elements related to medical imaging, primarily those identified in the ACR/NEMA standard but also additional ones like curves, derived or processed images, as well as other information media (e.g. speech, text).

The data model provides a repository (common structure) allowing consistent interoperability between all the components of the Medical Information System.

The data model has to be independent of any implementation constraint.

Consequently, the data model must describe:

- the data syntax, i.e. the entities of the medical imaging world and their static relationships,
- the data semantics, i.e. the behaviour of the entities and relationships,
- the data evolution, which allows a new modality or a new type of data acquisition or processing technique to be included.

The data model must allow the rules of data access control to be created and managed, without any recommendation concerning these rules. Similarly, it has to take into account the consistency and integrity constraints defined by the user.

The model will comprise two layers:

- 1) an upper one, including general information, such as referring physician attributes, patient attributes, medical history, modality independent attributes (examination requests, examination reports, etc), which can be shared by the different subsystems in charge of appointments, billing or medical records.
- 2) a lower one, which is modality dependent. Its entities are related to acquisition techniques and image processing. This level is more difficult to model, because:
 - each modality may have its own specific attributes,
 - the acquisition type, the image processing description, and their resulting images are a priori unknown and may evolve.

Consequently, a generic model has to be defined, in order to describe the way entities are built rather than describing the entities them-selves, and to represent their behaviour. A major advantage of this approach is that it enables to build "intelligent" interfaces, able to automatically insert raw or processed data, or to assist the query of the database.

3- Common functional model

Functional modeling aims at listing and describing the services performed by the MIMOSA system.

Suitable descriptions of these functions must detail the kind of information used in input, the kind of processing applied to the data and the output they generate. Such an analysis has to be as generic as possible to remain independent of possible implementations. As an example the interpretation of an examination usually results in a report which is generally (but not necessarily) produced and managed within a RIS. Here is the list of services related to this example:

- examination information retrieval,
- interpretation results identification,
- interpretation results storage.

This analysis will have to be done in several European hospitals, in order to ensure maximum generality of the model. Interviews and analysis of the current procedures (even if they are based on films) are suitable means to gather information.

4- Common operational model.

The previous analysis allows to decompose the procedures into atomic functions. The operational model aims at representing the way atomic functions have to be arranged in time to ensure a suitable functioning and efficacy of the system. In particular, the events triggering the functions have to be properly identified.

Examples:

- Intelligent pre-fetching of the previous examinations of a patient, according to specific rules taking into account the suspected pathology and the nature of the previous examinations
- Autorouting of the new examinations to be interpreted on a workstation
- Automatic purging of the interpreted examinations on workstations and short term archives.

The previous examples illustrate that the elaboration of an operational model requires a deep understanding of the current procedures and constraints, which needs a close collaboration with all users.

3) OPEN SYSTEMS

We will define 'open systems' as environments consisting of products and technologies that are designed and implemented in accordance with 'standards' that are vendor independent and commonly available, all of which enables communications with any compliant system.

The critical terms in the definition are: standards, vendor independent and commonly available. By implication, this means that the development environment and the production environment are clearly separated and, therefore, decisions as to development tools and production targets can, and should, be made independently, allowing the user to choose 'best of breed' for both environments. Tools in the development environment run on multiple platforms. The actual platform will be insulated from the user by a set of common interfaces based on published interfaces. In production, applications will run on multiple, heterogeneous platforms from multiple suppliers.

There are three characteristics that are the driving forces behind the push for open systems:

- portability: single applications can operate on a multiplicity of hardware platforms from several vendors;
- scalability: single applications can operate on small, medium and large systems;
- interoperability: applications can share processes and data regardless of where data or instructions are stored by utilizing process-to-process communications.

While the building of open systems bearing these characteristics will be facilitated by the publication of the appropriate standards from the standards bodies, applications exhibiting those characteristics can be built today using computer aided engineering (CASE) tools which target multiple environments.

In most cases it is difficult to build a completely open environment because of the need to coexist with existing applications. In fact, of the three main characteristics of open systems, interoperability is the most challenging because it typically dictates the use of a pragmatic set of available services that may be inconsistent with evolving standards e.g., internet protocols (TCP/IP) are ubiquitous, but are inconsistent with Open System Interconnect (OSI) standards.

Building open applications requires an application development environment that is open in multiple dimensions:

- Based on vendor-transcendent repository and tool standards (e.g. those defined by ANSI, OSF, ISO).
- Able to enforce use of standard application programming interfaces (APIs) by developers.
- Able to accept integration of another vendor's tools without control or involvement of the application development vendor.
- Able to target multivendor, heterogeneous run-time platforms.

Open development environments trade off productivity and effectiveness for the strategic flexibility of mixing tools and diversifying dependence.

4) MEDICAL IMAGE MANAGEMENT SYSTEM

The cornerstone services to be implemented in a Medical Image Management System are Library Services, Search and Retrieval, and Compound Image Services. A Medical Image Management System includes both images and related information such as examination reports (speech, text), demographic data.

Major services of medical image management systems

Library Services:

- provide logical views of images and related data, authorize user access to this information, direct data to various storage stages, keep an audit trail on information that are used.

Search and retrieval Services:

- provide end-user access to images using basic relational data, partial indexed data (key words/phrases), full indexed data, or context-related algorithms.

Compound Image Services:

- compound image services provide languages, specifications and tools to develop applications and convert image formats.

Other services of medical image management systems

Mail Agents and Transports Services:

- provide the store and forward transport to WAN and LAN communications, provide local agents.

Multimedia Database Services (managing image, text, speech):

- store and handle large strings of data representing text, graphics, or images as well as data (provide traditional services such as storage, logging and recovery, locking and so forth).

Security Services:

- ensure authorized image deliveries through encryption and provide authentication (signature) routines.

Administrative Tools:

- provide administrative tools for configuring, tuning and monitoring applications and networks.

5) CLIENT/SERVER ARCHITECTURE

Client/Server is a subset of cooperative processing, i.e. a single application is broken up into tasks; these tasks are then run on two or more separate and independently functioning platforms.

For system effectiveness in advanced networks, several specific services must be provided for the attached devices, all growing in magnitude as the network expands:

- A directory service for finding the physical location of data and services;
- A naming service for ensuring that the labels assigned to destinations, files and nodes are unique across the network;
- A time-keeping service for ensuring that all network elements have compatible and accurate time representations for system management and backup capabilities;
- A mechanism for validating the correct performance of any new client or server on the network.

Key Technologies:

- Distributed relational databases supporting synchronized multiuser updates
- Application-development tools supporting development of applications that intend to cooperate synchronously and dynamically and operate on heterogeneous processor architectures
- Object-oriented data structures
- Network-communications processes that are topology insensitive
- Process-to-process communications that are network insensitive.

The full client/server model will enable development of applications that function across a variety of processing platforms. The full model will not limit micros to being the requester or the midrange or mainframe to being the server. The challenge is multifaceted.

Application development is likely to decentralize; consequently, a higher emphasis has to be placed on development of global data-processing and network architecture.

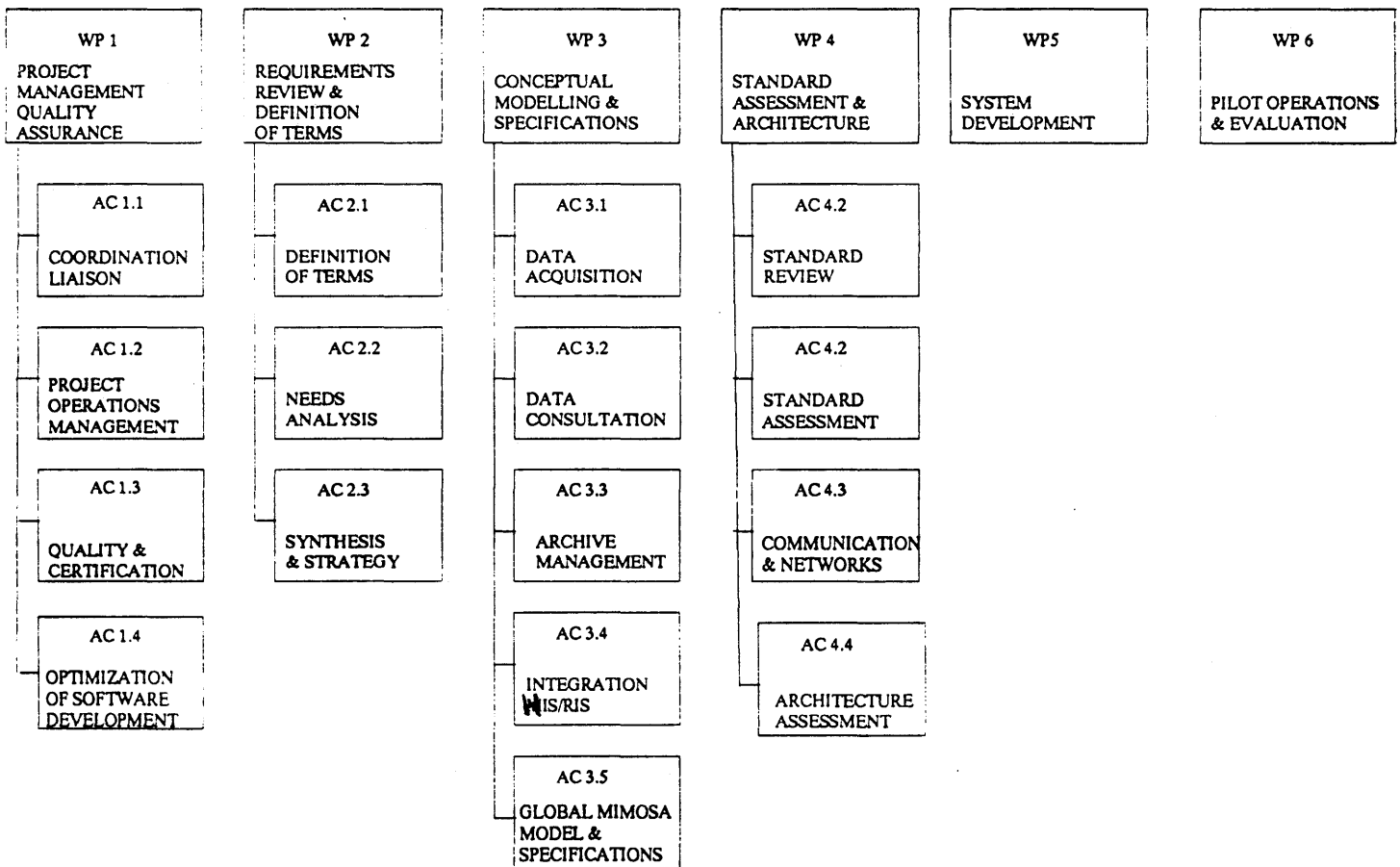
6) CLINICAL AND TECHNICAL EVALUATION

It is essential to evaluate the benefits brought by the MIMOSA system. The best way to perform this evaluation is to integrate the system in several real medical environments. Such a multi-site evaluation will allow:

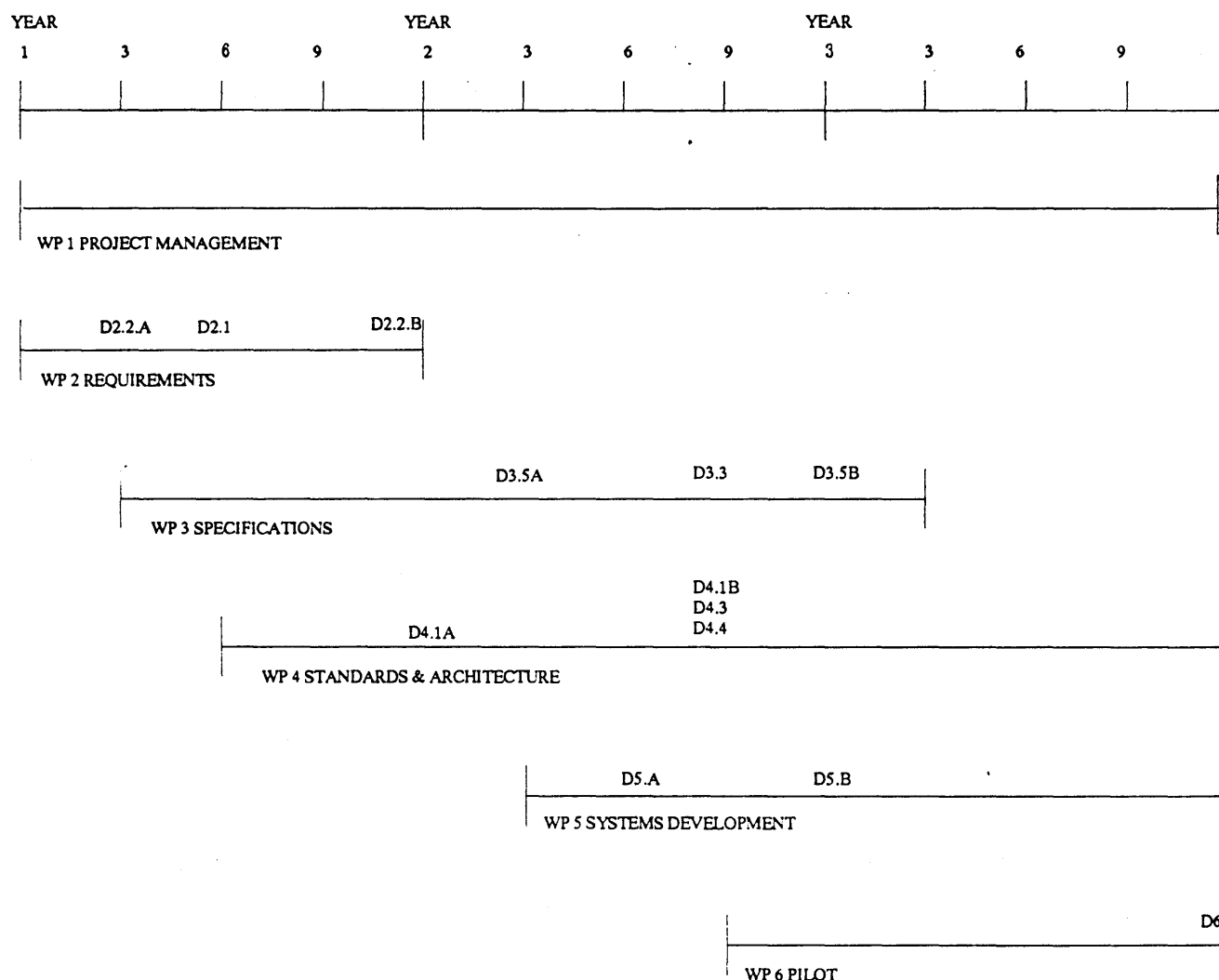
- the assessment of the effectiveness of the model (Is it suitable for the various kinds of data encountered in the different sites ? does the operational model meet the particular needs ?)
- the assessment of the generality of the architecture (Are the interfaces offered in the system suitable to interoperate with the different components available on each site: imaging equipments, workstations, RIS/HIS, storage systems ?)
- the assessment of the medical usefulness of the overall system (Has the system improved patient care ?).

The experiments carried out in the different sites will assess some or all of these aspects. The choice of which of these aspects will be done according to the specific possibilities offered at each site. The nature of these specificities can be technical (number and nature of imaging equipments which can be interfaced, existence and capacity of the image archive, existence of a RIS/HIS) or non-technical (interest of the people in particular aspects of the problem like the management of archives or image processing, or radiological daily routine).

2.2.2 Workbreakdown structure



2.2.3 Interrelationships of Workpackages



Workpackage 1 Project Management, will have a major workload in the first year to guarantee a smooth start of the project. Generally speaking also for the other workpackages the bulk of the workload is planned to be at the beginning and gradually decrease towards the end. Workpackage 2 Requirements, although formally ending on year 2 month 6 will have a follow-up in the sense that there will be a continuing monitoring of the evolution and trends in medical imaging. Workpackage 3 Modelling and Specifications will have a phased approach outlined in 2.2.4 hereafter.

In more general terms there is a continuous relationship between the different workpackages in an iterative process. For each workpackage there will be 3 phases: preliminary, detailed, final. The preliminary phase will end with a first output which will start the next workpackage. The findings in this next workpackage preliminary phase will feedback into the previous workpackage in the detailed phase. This detailed phase output will then guide the progress of the next workpackage into the detailed phase which in turn will output to the final phase of the previous workpackage. The final phase output will determine the final phase of the next workpackage.

2.2.4 WP 3 Phased Life-Cycle Approach

A structured step-wise approach to modelling with a three *phase* structure will be applied for each activity in this workpackage. Each phase comprises several tasks (see below).

Phases 1 and 2 encompass the conceptual level of the methodology (information modelling). Phase 3 is the organizational level (scenario and implementation).

For each task, the *input* documents or models and the *deliverables* are specified. For planning purposes, each task also includes requirements as to the needed *knowledge* and *skills* of the people involved.

PHASE 1 - PRELIMINARY STUDY

- Statement of Objectives
- Functional Model
- Conceptual Data Model
- Identification of Constraints
- Quality Criteria

PHASE 2 - DETAILED STUDY

- Detailed Functional and Data Models
- Integration of Constraints and Functional

PHASE 3 - ORGANIZATIONAL STUDY

- Scenario Design
- Design of Structures and Service Structures
- Organizational Considerations
- Integration with Existing Systems
- Requirements Specification for Communications

PHASE 1: PRELIMINARY STUDY

The objective of this phase is to specify the boundaries and the context of the overall modelling task. This is done by designing a high level (and therefore limited) business and data model.

Statement of objectives

Design of a functional model

The objective of this task is the definition of a *scope* for the modelling work as a whole. It represents the *context* in which the modelling is done, and therefore is the general *guideline* and *reference* for all the subsequent activities.

No scenario description is done at this point. Structures, information technology and sequencing aspects are all considered later.

The model should identify the parties involved in the problem, as well as the basic data flows between these parties.

Input: objectives of the modelling study

Deliverable: "context" functional model, with data flow candidates

Design of a global conceptual data model

The objective of this task is to identify the basic information objects (concepts) and their relationships relevant to the functional model completed in the previous task.

The guideline for this study should be the data flow candidates identified in the previous task.

Input: data flow candidates

Deliverable: general data model

Identification of constraints

This task focuses on the external constraints relevant to the modelled functional. This inventory will influence the detailed models (detailed study phase) as well as the organizational study.

Input: "context" functional model and global data model

Deliverable: check-list of constraints and their documentation

PHASE 2: DETAILED STUDY

The objective of this phase is to refine the general models produced by the preliminary study. The refinement process should proceed until it is felt that all the information relevant to the target functions has been identified and modelled.

Detailed functional and data models

Although these models are technically two activities, we blend them into one because of the parallel nature of the work (back and forth between the two models, each one influencing the other).

From the functional model point of view, experience shows that the global roles identified in the previous phase should be examined more closely (i.e. some internal functional functions relevant). Close attention should be paid here to avoid a too detailed study. The rule to be observed is that only functional functions generating and/or producing information relevant to the system should be studied.

From the conceptual data model point of view, two tasks should be handled:

- attribute inventory should be done for all the information objects identified in the global data model, from phase 1
- relationships have to be specified in detail (referencing problem).

Input: Phase 1 deliverable

Deliverable: detailed data and functional model

Integration of constraints and functional rules

This task is a cross-check of the detailed models produced in the data and functional models with the constraints and quality considerations identified in the previous phase.

The conceptual data model will probably need some more attention in order to specify the general functional rules governing the data.

Input: detailed functional and data models, constraints and quality considerations from the data and the functional model.

Deliverable: verified functional model, verified and completed conceptual data model

PHASE 3: ORGANIZATIONAL STUDY

Based on the deliverable of phase 2, and more specifically on the conceptual models produced, this phase will deal with:

- the organization of the functional relation into scenarios
- the organization of the conceptual data content into structures
- revisiting the produced structures in order to cover all organizational requirements
- revisiting the produced structures in order to cover all systems requirements.

Scenario design

A scenario will include such considerations as: responsibility transfers between parties, sequencing, time constraints, error handling, etc. Several scenarios (alternatives) can describe one functional relation.

Input: Phase 2 deliverable

Deliverable: set of scenarios

Design of structures and service structures

Organization of the conceptual data content into structures: grouping attributes into existing segments is a typical task here, aided by the methodology tool. This also includes service structures, the contents and structure of which depend on the scenarios.

Input: data model, process model

Deliverable: structures and service structures

Organizational requirements

All structures are considered in this task against defined organizational requirements. The layout and/or structure of the structures could be modified here. A possibility exists that new structures might result from this task.

Input: organizational requirements, structures

Deliverable: adapted structures

Requirements for interchange services

The requirements for interchange service should be made, e.g.:

- priority and model
- communication channels
- expected model of confirmation and deadlines.

In this task the produced structures are examined in order to adapt them to the available communication service, e.g. X400, X500, OSI TP or FTAM. Slight modifications to message layout and/or structure could result due this mapping.

Input: structures from organizational requirements

Deliverable: modified structures

2.3 OVERALL PROJECT SYNTHESIS

2.3.1 Goal description

Form M4A

FORM M4A: Goal Description
(Overall Plan)

Project Title
MIMOSA

Coordinator's Reference No.	12258
Programme	AIM
Date of Preparation	16/09/1991
Sheet No.	1 of 2

Description	Goal Type
Build an open system environment for managing, exchanging and distributing health care images.	MG
Specify user requirements, in terms of information management and communication in the field of medical imaging.	MG
Model the medical images system and relevant data structure and the interfaces to the outside world, according to the requirements and the existing standards, leading to European recommendations for a standard image data model.	MG
Implement the MIMOSA standard image data model in order to evaluate its main functionalities: reformatting of acquired images, archiving strategies, access from various image workstations, HIS/RIS link.	MG
Definition of an European standard for medical images data structures for input to CEN.	OG
Review of current developments in Medical Image Systems.	OG
Formal specifications of data, data flow, actors of a Medical Images System.	OG
Create a public data dictionary for all data elements for medical image types.	MG
Build data browsing tools adapted to clinical users and specific clinical requirements, allowing adequate consultation of images and related data.	SG

FORM M4A: Goal Description
(Overall Plan)

Project Title
MIMOSA

Coordinator's Reference No.	12258
Programme	AIM
Date of Preparation	16/09/1991
Sheet No.	2 of 2

(Continued...)

Description	Goal Type
Develop Archiving Functions of Medical Imaging Systems: data prefetching, data visibility, data filtering, data deletion, and automated data storage.	SG
Participate in development of standards for exchange of medical images.	MG
Develop links to Medical Image Data Base and to related information from radiological Information System and Hospital Information System.	OG
Integration of MIMOSA Medical Images System in real PACS environment at 8 pilot locations spread over Europe	MG
Evaluate the potential of MIMOSA to establish a multimodality teaching medical images data base	MG

2.3.2 Workpackage List

Form M4B

FORM M4B: Workpackage List
(Overall Plan)

Project Title
MIMOSA

Coordinator's Reference No.	12258
Programme	AIM
Date of Preparation	16/09/1991
Sheet No.	1 of 2

Number of Partners: 8 Duration (Months): 36 Total Manpower (MM): 523

Workpackage Number	Activity Number	Workpackage Title	Partnr Code	Man Months
1		PROJECT MANAGEMENT AND QUALITY ASSURANCE	P01	46
1	1	COORDINATION/LIAISON	P01	6
1	2	PROJECT OPERATIONAL MANAGEMENT	P02	12
1	3	QUALITY AND CERTIFICATION	P01	2
1	4	OPTIMIZATION OF SYSTEM AND SOFTWARE DEVELOPMENT	P02	4
2		REQUIRMENTS REVIEW AND DEFINITION OF TERMS	P03	56
2	1	DEFINITION OF TERMS	P06	10
2	2	NEEDS ANALYSIS	P03	24
2	3	SYNTHESIS AND STRATEGY	P01	22
3		CONCEPTUAL MODELLING AND SPECIFICATIONS	P03	151
3	1	DATA ACQUISITION	P06	16
3	2	DATA CONSULTATION	P01	16
3	3	ARCHIVE MANAGEMENT	P01	16
3	4	INTEGRATION HIS/RIS	P01	17

FORM M4B: Workpackage List
(Overall Plan)

Project Title
MIMOSA

Coordinator's Reference No.	12258
Programme	AIM
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(Continued...)

Workpackage Number	Activity Number	Workpackage Title	Partnr Code	Man Months
3	5	GLOBAL MIMOSA MODEL AND SPECIFICATIONS	P03	24
4		STANDARDS ASSESSMENT AND ARCHITECTURE	P06	66
4	1	STANDARDS ASSESSMENT	P06	12
4	2	STANDARDIZATION PARTICIPATION	P04	6
4	3	COMMUNICATIONS AND NETWORKS	P08	4
4	4	ARCHITECTURE ASESMENT	P01	3
5		SYSTEM DEVELOPMENT	P01	94
6		PILOT OPERATIONS AND EVALUATIONS	P03	110

2.3.3 Workpackage descriptions

Form M4C

FORM M4C: Workpackage/Activity
Description
(Overall Plan)

Coordinator's Reference No. 12258
Programme AIM
Date of Preparation 16/09/1991
Sheet No. 1 of 1

Project Title
MIMOSA

Workpackage	Activity	Workpackage/Activity Title
1		PROJECT MANAGEMENT AND QUALITY ASSURANCE

Starting Event: START OF PROJECT

Description

A Project Management team provided by the 2 industrial partners will:

- Establish optimal coordination with CEC and within consortium.
- Concertate with other relevant projects.
- Insure accurate time and resource projections for the project.
- Empirically measure productivity and changes in productivity.
- Develop accurate, optimized project schedules based on resources available.
- Master the learning curve associated with the widespread implementation of system development methodologies and other emerging technologies.
- Optimize the effectiveness of installed development technologies.

Quality Insurance will be an integral part of the project and will -Monitor the submission and appropriate distribution of the deliverables.

- Continually assess possible risks and propose preventive actions.
- Measure the functional quality, the degree of fulfillment of functional requirements, and the technical quality, correctness and efficiency of the implemented system.
- Organize and manage formal certification.

A Project Coordination Committee of representatives of all partners will be the supreme body. Workpackage leaders in charge for each workpackage will report to this committee and for the operational project management duties to the project management team.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	SENIOR ENGINEER	1	12.0	6.0	6.0	0.0	0.0	24.0
P02	SENIOR CONSULTANT	1	12.0	6.0	4.0	0.0	0.0	22.0

FORM M4C: Workpackage/Activity
Description
(Overall Plan)

Coordinator's Reference No. 12258
Programme AIM
Date of Preparation 16/09/1991
Sheet No. 1 of 1

Project Title
MIMOSA

Workpackage	Activity	Workpackage/Activity Title
2		REQUIRMENTS REVIEW AND DEFINITION OF TERMS

Starting Event: DETAILED WORKPLAN

Description

Objectives : This package aims at reviewing the general requirement of a Medical Imaging Management System. Requirements will be specified by interviewing european physicians, medical imaging researchers and hospital managers to understand how image data are produced (acquisition, processing) and used (what, how, where and when). The obtained information will be used :

- 1) to define a common vocabulary in medical imaging,
- 2) to assess the adequacy of existing standards,
- 3) to prepare the modeling of image data structure (WP3),
- 4) to identify the interfaces with the environment (to image sources, archives, image workstations and HIS),
- 5) to precisely define pilot operations able to evaluate the MIMOSA concept.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	SENIOR ENGINEER	1	6.0	0.0	0.0	0.0	0.0	6.0
P03	JUNIOR SCIENTIST	2	12.0	0.0	0.0	0.0	0.0	12.0
P03	SENIOR SCIENTIST	1	24.0	0.0	0.0	0.0	0.0	24.0
P04	SCIENTIST A	1	2.0	0.0	0.0	0.0	0.0	2.0
P06	JUNIOR SCIENTIST	2	3.0	0.0	0.0	0.0	0.0	3.0
P06	SENIOR SCIENTIST	1	3.0	0.0	0.0	0.0	0.0	3.0
P08	SENIOR SCIENTIST	2	2.0	0.0	0.0	0.0	0.0	2.0
P09	PHYSISIST	0	4.0	0.0	0.0	0.0	0.0	4.0

FORM M4C: Workpackage/Activity
Description
(Overall Plan)

Coordinator's Reference No. 12258
Programme AIM
Date of Preparation 16/09/1991
Sheet No. 1 of 1

Project Title
MIMOSA

Workpackage	Activity	Workpackage/Activity Title
3		CONCEPTUAL MODELLING AND SPECIFICATIONS

Starting Event: FIRST REPORT OF WP2 REQUIREMENTS.

Description

A methodological framework will be implemented to support lifecycle from initial conceptual design to implementation and maintenance of MIMOSA. A common conceptual model recognizes 3 levels of abstraction and 2 viewpoints of information. Formal Description Techniques (FDTs) facilitate the step-wise refinement of both data and process aspects. The methodological framework provides the integration of independent FDTs into a complete and consistent set of tools for the specification of the MIMOSA system. The framework also provides rules for model interplay.

The 3 layers lead to a step-wise approach to the design of MIMOSA:

- The conceptual layer is an abstract specification of the requirements, describing the functions which must be provided (functional model) as well as the information (data model) needed to perform these functions. In one word the WHAT? of MIMOSA.
- The organizational layer describes an operational model. It is still abstract and independent of the products that will be used. It deals with the dynamic aspects of MIMOSA: WHEN? WHO? WHERE?
- The layer of implementation specifications represents the set of technical solutions which will be used for the implementation and involves the products: HOW? of MIMOSA.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	ENGINEER	2	18.0	9.0	4.0	0.0	0.0	31.0
P01	SENIOR ENGINEER	1	15.0	5.0	2.0	0.0	0.0	22.0
P02	CONSULTANT	2	5.0	0.0	0.0	0.0	0.0	5.0
P02	SENIOR CONSULTANT	1	11.0	3.0	2.0	0.0	0.0	16.0
P03	JUNIOR SCIENTIST	2	10.0	5.0	0.0	0.0	0.0	15.0
P03	SENIOR SCIENTIST	1	13.0	9.0	0.0	0.0	0.0	22.0
P04	SCIENTIST B	2	1.0	1.0	0.0	0.0	0.0	2.0
P05	SCIENTIST/MD	0	1.0	5.0	0.0	0.0	0.0	6.0
P06	SENIOR SCIENTIST	1	3.0	3.0	0.0	0.0	0.0	6.0
P08	JUNIOR SCIENTIST	3	5.0	5.0	2.0	0.0	0.0	12.0
P08	SENIOR SCIENTIST	2	5.0	5.0	2.0	0.0	0.0	12.0
P09	PHYSICIST	0	2.0	0.0	0.0	0.0	0.0	2.0

FORM M4C: Workpackage/Activity
Description
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Date of Preparation 16/09/1991
Sheet No. 1 of 1

Project Title
MIMOSA

Workpackage	Activity	Workpackage/Activity Title
4		STANDARDS ASSESSMENT AND ARCHITECTURE

Starting Event: PRELIMINARY REPORT OF CONCEPTUAL MODELLING

Description

Objectives: To assess the standards and architectures as specified or available in the community at large and generates as part of the MIMOSA project and to assess them in light of the requirements of this project.

Technical approach:

Using formal tools, (CASE, simulation, conversion programs) such standards and architectures will be evaluated such that a detailed analysis of what is available will be assessable in formal form prior to implementation.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	SENIOR ENGINEER	1	0.0	6.0	0.0	0.0	0.0	6.0
P02	CONSULTANT	2	0.0	2.0	0.0	0.0	0.0	2.0
P03	SENIOR SCIENTIST	1	0.0	4.0	4.0	0.0	0.0	8.0
P04	SCIENTIST A	1	6.0	3.0	3.0	0.0	0.0	12.0
P04	SCIENTIST B	2	6.0	3.0	3.0	0.0	0.0	12.0
P05	SCIENTIST/MD	0	0.0	4.0	0.0	0.0	0.0	4.0
P06	JUNIOR SCIENTIST	2	3.0	3.0	2.0	0.0	0.0	8.0
P06	SENIOR SCIENTIST	1	6.0	2.0	0.0	0.0	0.0	8.0
P08	SENIOR SCIENTIST	2	4.0	0.0	0.0	0.0	0.0	4.0
P09	PHYSICIST	0	0.0	2.0	0.0	0.0	0.0	2.0

FORM M4C: Workpackage/Activity
Description
(Overall Plan)

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MIMOSA

Coordinator's Reference No. 12258
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Workpackage	Activity	Workpackage/Activity Title
5		SYSTEM DEVELOPMENT

Starting Event: PRELIMINARY REPORT OF WP4 AND FIRST MIMOSA OVERALL SPEC.

Description

The objectives are to have the core of the MIMOSA system (i.e. a runtime, version and its related documentation) ready for WP6. This core system will run on various hardware systems.

Based on the specifications of WP3 and the recommendations of WP4, the core of the MIMOSA system will be implemented. The best suited implementation technique will be chosen for every component of the system identified in WP4-2: procedural or object-oriented. The grouping of service elements into processes will allow the development of several processes in parallel. The service elements will be implemented (i.e. coded, debugged, validated and documented) one by one, and only then integrated in the whole system.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	ENGINEER	2	0.0	16.0	12.0	0.0	0.0	28.0
P01	SENIOR ENGINEER	1	0.0	8.0	6.0	0.0	0.0	14.0
P03	JUNIOR SCIENTIST	2	0.0	6.0	0.0	0.0	0.0	6.0
P03	SENIOR SCIENTIST	1	0.0	6.0	0.0	0.0	0.0	6.0
P05	SCIENTIST/MD	0	0.0	12.0	8.0	0.0	0.0	20.0
P08	JUNIOR SCIENTIST	3	0.0	4.0	6.0	0.0	0.0	10.0
P08	SENIOR SCIENTIST	2	0.0	6.0	4.0	0.0	0.0	10.0

FORM M4C: Workpackage/Activity
Description
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Project Title
MIMOSA

Workpackage	Activity	Workpackage/Activity Title
6		PILOT OPERATIONS AND EVALUATIONS

Starting Event: FIRST SPECIFICATIONS AND DOCUMENTATION OF WP5 SYSTEMS DEVELOPMT

Description

This package aims at validating the effectiveness of the MIMOSA concept in several specific PACS environments, this validation clearly has three aspects: 1. the integration of MIMOSA in a real PACS environment will assess the generality of the capabilities offered by MIMOSA, and the pertinancy of architectural choices. 2. the utilization of the system in the medical practice will highlight the benefits and shortcomings of the system. 3. the potential of MIMOSA in establishing a multimodality teaching image data base will be evaluated.

WP5 will implement the kernel of MIMOSA. The integration of this kernel in specific PACS environments will obviously require adaptations. The degree of complexity of this adaptation will assess the generality of MIMOSA: standards used in MIMOSA for accessing and representing data, possibilities offered to insert modules to convert formats, adequacy of MIMOSA to inter-operate with existing information system (HIS, RIS), capacity to remain independent of the physical storage of images, etc. Once integrated in a PACS configuration, the MIMOSA system will be able to be used by radiologists and clinicians in the current medical practice. The capacity of the system to satisfy the daily user requirements will be evaluated. Opinions of users (doctors, technicians) will be gathered; objective results will also be collected like measurements of data availability.

Partner Code	Labour Category	Rate Code	Yr 1 M-mths	Yr 2 M-mths	Yr 3 M-mths	Yr 4 M-mths	Yr 5 M-mths	Total M-mths
P01	ENGINEER	2	0.0	12.0	16.0	0.0	0.0	28.0
P01	SENIOR ENGINEER	1	0.0	6.0	10.0	0.0	0.0	16.0
P03	JUNIOR SCIENTIST	2	0.0	4.0	6.0	0.0	0.0	10.0
P03	SENIOR SCIENTIST	1	0.0	6.0	10.0	0.0	0.0	16.0
P05	SCIENTIST/MD	0	0.0	8.0	12.0	0.0	0.0	20.0
P09	PHYSICIST	0	0.0	6.0	14.0	0.0	0.0	20.0